A Bibliometric Analysis of R&D at Environment Canada
Outline

A Bibliometric Analysis of R&D at Environment Canada

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Context of the study

- A Science-Metrix bibliometric study conducted in 2006 (25 Years of Canadian Environmental Research) highlighted EC’s leading position in Canadian and international environmental research.

- The primary objective of the 2006 study was to measure and compare the scientific output of countries and international institutions using a definition of the environmental research domain.

- The main goal of this new bibliometric analysis is to compile indicators on EC’s entire scientific production between 2003 and 2007 at the level of:
  - S&T Branch and its Directorates;
  - other Branches and EC as a whole;

- The primarily focus of this bibliometric analysis is to provide performance indicators to examine: 1) Output, 2) Impact, 3) Collaboration, and 4) Specialization

- Between 2003 and 2007, EC produced 3,016 peer-reviewed papers in journals indexed in Scopus, i.e., 600 papers per year on average.
- The S&T Branch is the main scientific contributor, with 2,600 papers (520 papers per year on average), or 85% of EC’s total output.
- The annual output of the S&T Branch (and EC) was relatively stable over the five-year period with a peak in 2006.
- The main science contributors within the S&T Branch are:
  - AST: ~196 papers per year; 38%* of S&T branch
  - WST: ~206 papers per year; 40%* of S&T branch
  - WLS: ~110 papers per year; 21%* of S&T branch

*The sum of % exceeds 100% (if all directorates are listed) because of intramural collaborations (co-authorship)
Trends in EC’s scientific output (2003–2007)

Total number of scientific papers produced by EC and by Branch*

- EC
- S&T
- ESB
- MSC
- Other/Unknown

Share (%*) of EC scientific papers by Branch

*Data prior to the creation of S&T Branch was compiled based on the location of individual employees or of their groups.

*The sum of % exceeds 100% because of intramural collaborations (co-authorship).
S&T Branch scientific output (2003–2007)

Total number of scientific papers produced by S&T Branch Directorates

Share (%*) of S&T Branch by Directorate

*The sum of % exceeds 100% because of intramural collaborations (co-authorship)
Output of Research Scientists (RES)

- 63% of EC papers involved at least one RES (2003-2007)
- 72% of the S&T Branch papers were authored by RES
- The most productive and high-impact S&T directorates have the highest proportion of papers authored by RES: AST, WLS and WST
Scientific impact (Citation counts)

- EC papers received 70% more citations than the world average.
- The impact of EC decreased between 2005 and 2007. However, data from the coming years would be required to confirm this trend.
- The main science contributors within the S&T Branch have the greatest impact:
  - AST: ~110% more citations than the world average
  - WST: ~76% more citations than the world average
  - WLS: ~73% more citations than the world average
Scientific Impact (Citation counts)

Annual scientific impact of EC and Branches

Scientific impact of EC, Branches and S&T Branch Directorates, 2003-2007

- EC
- S&T
- AST
- WST
- WLS
- SRA
- ESTC
- STS*
- MSC
- ESB

Average relative citation (ARC)

World Level

* Non-significant
Scientific impact by specialty

- EC papers published in generalist and interdisciplinary Environmental Sciences (General) journals have the greatest impact.
- EC papers have a higher impact than the Canadian impact level in three other specialties: 1) Pollution, Environmental Toxicology and Health, 2) Climate, Meteorology and Atmospheric Sciences, and 3) Ecology and Biological Resources.

![Graph showing scientific impact by specialty](image)
Scientific collaboration (2003–2007)

- EC’s scientific output is mainly done in collaboration: 83% of EC (and S&T Branch) papers are co-authored with external collaborators.
- The % of EC papers with national collaborators remained relatively stable over the last 5 years while international collaborations increased by 10 % points.
- The Directorates that have most increased their international collaboration rates are: WLS (19 % points) and AST (14 % points).

EC scientific collaboration by type (2003–2007)

S&T Directorate international scientific collaboration (2003–2007)
Collaboration rate by S&T Directorate

- AST and ESTC collaborated equally with international and national institutions.
- SRA, WLS and WST collaborate twice as often with national institutions as with international collaborators.

Scientific collaboration by Branches and S&T Directorates (2003–2007)
The WST is an important source of intramural collaborators within and outside the S&T Branch.

The two S&T Directorates that collaborated the most with other EC Branches are: AST with MSC and WLS with ESB.

* SRA not presented
The distribution of bilateral collaborations with sectors in Canada are similar at all levels: EC, Branches and S&T Directorates.

This distribution remained quite stable over the five-year period.

The main EC collaborators are Canadian universities and other federal government departments (OGDs).
Canadian collaboration network of S&T Directorates
Main international & national collaborators

- The main international collaborators are governmental organizations.
- The main national collaborators are universities and federal departments.

<table>
<thead>
<tr>
<th>International Institution</th>
<th># Collabo</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOAA - National Oceanic and Atmospheric Administration</td>
<td>98</td>
</tr>
<tr>
<td>NASA</td>
<td>64</td>
</tr>
<tr>
<td>USGS - US Geological Survey</td>
<td>61</td>
</tr>
<tr>
<td>CNRS - Centre national de la recherche scientifique</td>
<td>61</td>
</tr>
<tr>
<td>NERI - National Environmental Research Institute (Denmark)</td>
<td>44</td>
</tr>
<tr>
<td>University of Colorado at Boulder</td>
<td>42</td>
</tr>
<tr>
<td>Helmholtz-Gemeinschaft Deutscher Forschungszentren</td>
<td>41</td>
</tr>
<tr>
<td>UCAR - University Corporation for Atmospheric Research</td>
<td>39</td>
</tr>
<tr>
<td>Max Planck Society</td>
<td>38</td>
</tr>
<tr>
<td>Chinese Academy of Sciences</td>
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<tr>
<td>Met Office (UK)</td>
<td>35</td>
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<tr>
<td>University of Alaska Fairbanks</td>
<td>31</td>
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<tr>
<td>ETH - Swiss Federal Institution for Technology</td>
<td>31</td>
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<tr>
<td>EPA - Environmental Protection Agency</td>
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<tr>
<td>US Fish &amp; Wildlife Service</td>
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<tr>
<td>Lancaster University</td>
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<tr>
<td>NILU - Norwegian Institute for Air Research</td>
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<td>DOE - US Department of Energy</td>
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<tr>
<td>Caltech - California Institute of Technology</td>
<td>25</td>
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<tr>
<td>Norwegian Polar Institute</td>
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</table>

<table>
<thead>
<tr>
<th>Canadian Institution</th>
<th># Collabo</th>
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</thead>
<tbody>
<tr>
<td>University of Toronto</td>
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<tr>
<td>Carleton University</td>
<td>173</td>
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<tr>
<td>University of Saskatchewan</td>
<td>171</td>
</tr>
<tr>
<td>DFO - Fisheries and Oceans Canada</td>
<td>165</td>
</tr>
<tr>
<td>University of Waterloo</td>
<td>122</td>
</tr>
<tr>
<td>University of Guelph</td>
<td>108</td>
</tr>
<tr>
<td>University of British Columbia</td>
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<td>University of Victoria</td>
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<tr>
<td>McGill University</td>
<td>104</td>
</tr>
<tr>
<td>Simon Fraser University</td>
<td>90</td>
</tr>
<tr>
<td>NRCAN - Natural Resources Canada</td>
<td>74</td>
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<tr>
<td>York University</td>
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<tr>
<td>University of Alberta</td>
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<td>Health Canada</td>
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<td>Queen's University</td>
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<td>University of Ottawa</td>
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<td>McMaster University</td>
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<tr>
<td>Dalhousie University</td>
<td>56</td>
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<tr>
<td>University of New Brunswick</td>
<td>56</td>
</tr>
<tr>
<td>Trent University</td>
<td>52</td>
</tr>
</tbody>
</table>
International scientific collaboration is strongly associated to the scientific impact of EC papers (this is usually the case in science)

In particular, papers produced both with international and national collaborators have the highest impact among collaboration settings
Specialization of S&T Directorates

Distribution of papers from the S&T Branch by specialty* (2003–2007)

* Determination of the specialty of papers is based on the classification of journals; the analysis of alignment of S&T would benefit from classifying papers using a keyword approach.
Conclusion

- EC had a high level of scientific output, with 3,016 papers in 5 years
- EC also has a high level of scientific impact, particularly in: 1) Environmental Science – General, 2) Pollution, Environmental Toxicology and Health, 3) Climate, Meteorology and Atmospheric Sciences, and 4) Ecology and Biological Resources
- Together, AST, WST and WLS contribute to more than 80% of EC’s output of scientific papers and have a high level of scientific impact
- Research scientists are responsible for 63% of EC’s output of scientific papers
- EC has strong links with national universities and international governmental organizations
- EC produces papers in most specializations of environmental research; S&T Branch directorates are generally specialized in one or two specific areas
Contact information

Presentation to:
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www.rd-reports.com
Annex 1: Approach and methods

- This study used the Scopus bibliographic database: 33 million records in 15,000 peer-reviewed scientific journals

- 3,494 papers from EC authors were retrieved in the database for the five-year period (2003-2007) — 3,016 were retained for the analysis as they are peer-reviewed scientific papers

- Each EC paper was associated to a Branch based on a list of author affiliation provided by EC. Papers from the S&T Branch were also linked to the Directorate. In the case of multiple authors, the papers were attributed to more than one Branch/Directorate

- Papers were also classified on 7 topics using a classification developed for EC in the 2006 study which is based on journals’ aim & scope
Annex 2: Bibliometric databases provide valuable data

- Counts of papers by year (trends)
- Delineation of scientific fields/subfields
- Counts of papers by researcher
- Measures of collaboration between researchers
- Counts of papers by institution, province, region and country
- Measures of collaboration between researchers, institutions, provinces and countries
- Counting the number of citations: the number of times a paper appears in the references of other papers to measure its scientific uptake/impact
Annex 3: Bibliometric indicators

**Number of papers:** Counts based on authors’ affiliation provided by EC

**Specialization index (SI):** Measures the intensity of research of an entity (e.g., a EC) in a given field relative to the intensity of the world in the same field.

\[
SI = \frac{X_F / X_T}{R_F / R_T} = \frac{\text{(EC papers in water resources /All EC Papers)}}{\text{(World Papers in water resources/All World Papers)}}
\]

- \(SI > 1\) → EC is specialized in water resources
- \(SI < 1\) → EC is not specialized in water resources

**Average of relative citations (ARC):** Measures the *actual scientific impact* of research conducted by an entity based on the average number of citations its papers received relative to the average number of citations received by world papers. Each paper’s citation count is normalized to account for different citation patterns across subfields of science.

- \(ARC > 1\) → Canada’s research is more cited than the average world research
- \(ARC < 1\) → Canada’s research is less cited than the average world research
**Bibliometric indicators (cont’d)**

**Collaboration rate:** The relative intensity of collaboration of an entity at different aggregation levels (e.g., international, national, or institutional). The rate is calculated by dividing the number of papers co-authored with a collaborator by the entity’s total number of papers.

\[
\text{Int’l collaboration rate} = \frac{\text{(EC papers co-authored with foreign countries)}}{\text{(All EC papers)}}
\]

**Collaboration network:** Based on a matrix of papers in co-authored between pairs of Branches, S&T Directorates and Canadian institutions. The number on the circle represent the total number of papers.

<table>
<thead>
<tr>
<th></th>
<th>WLS</th>
<th>WST</th>
<th>AST</th>
</tr>
</thead>
<tbody>
<tr>
<td>WLS</td>
<td>0</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>WST</td>
<td>30</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>AST</td>
<td>0</td>
<td>60</td>
<td>0</td>
</tr>
</tbody>
</table>
## Annex 4: List of acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARC</td>
<td>Average of relative citations</td>
</tr>
<tr>
<td>ASTD</td>
<td>Atmospheric Science and Technology (Directorate)</td>
</tr>
<tr>
<td>EC</td>
<td>Environment Canada</td>
</tr>
<tr>
<td>ESB</td>
<td>Environmental Stewardship Branch</td>
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<tr>
<td>ESTC</td>
<td>Environmental Science and Technology Centre</td>
</tr>
<tr>
<td>MSC</td>
<td>Meteorological Service of Canada</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
</tr>
<tr>
<td>RES</td>
<td>Research Scientist</td>
</tr>
<tr>
<td>S&amp;T</td>
<td>Science and Technology</td>
</tr>
<tr>
<td>SRA</td>
<td>Science and Risk Assessment (Directorate)</td>
</tr>
<tr>
<td>STS</td>
<td>Science and Technology Strategies (Directorate)</td>
</tr>
<tr>
<td>WLS</td>
<td>Wildlife and Landscape Science (Directorate)</td>
</tr>
<tr>
<td>WST</td>
<td>Water Science and Technology (Directorate)</td>
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</tbody>
</table>